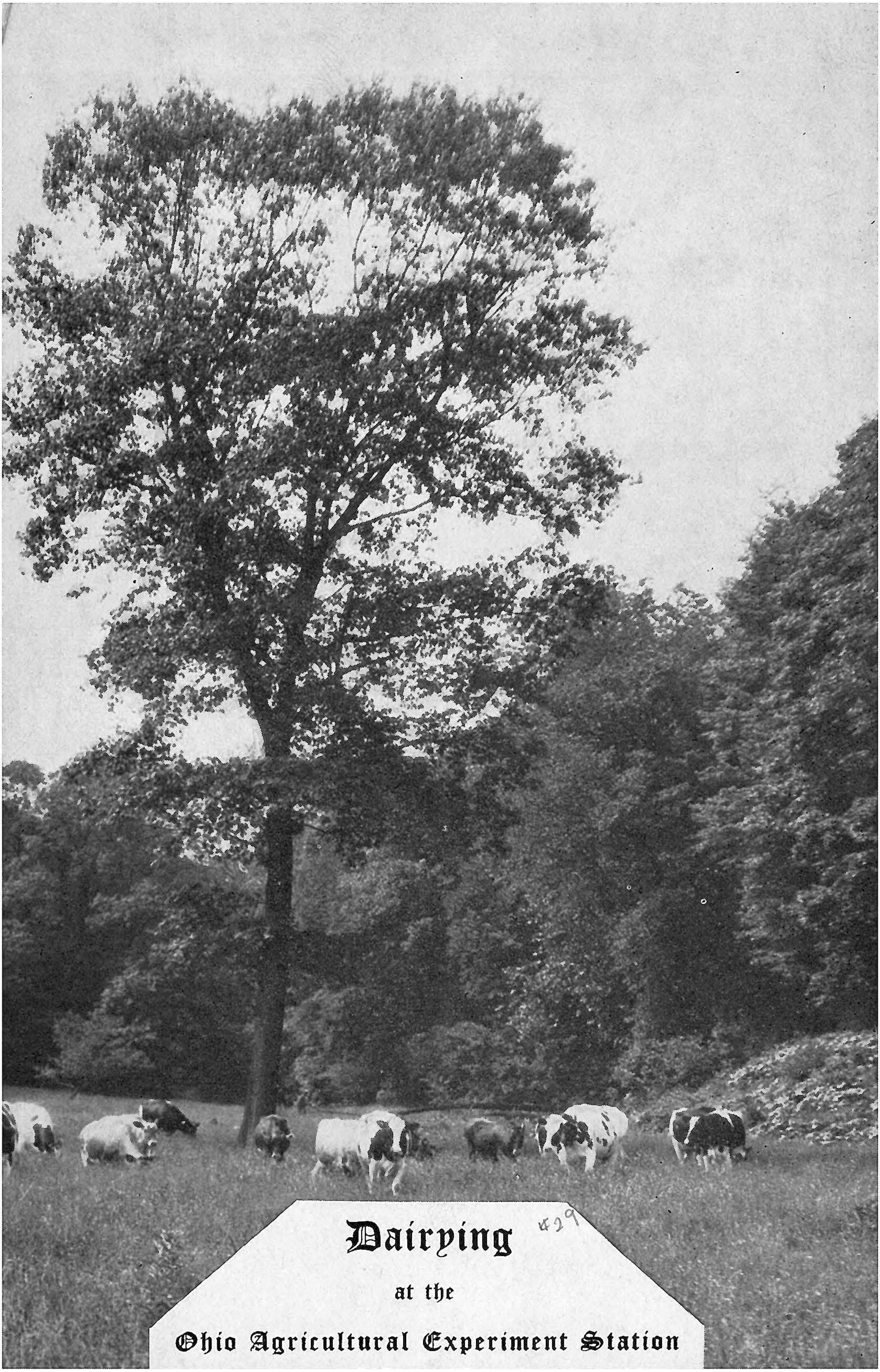

Dairying

#29

at the

Ohio Agricultural Experiment Station

Dairying

at the

OHIO AGRICULTURAL EXPERIMENT STATION

Wooster, Ohio

Special Circular No. 29 August, 1930

OHIO AGRICULTURAL EXPERIMENT STATION

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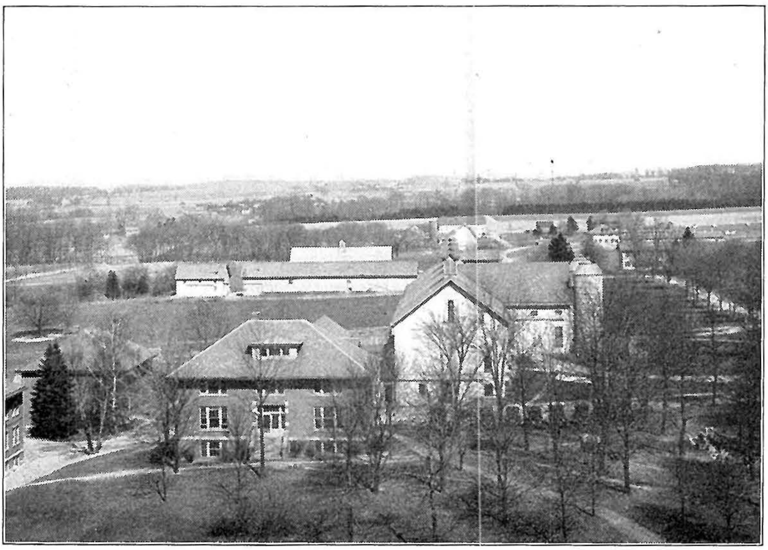

Dairy Building and Dairy Barn at the Ohio Agricultural Experiment Station

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THE DAIRY HERD

The Station dairy herd consisting of over 90 animals is kept primarily for experimental purposes, and not as a fine breeding or show herd.

The aim is to breed good producers by selecting males from high-producing ancestors. Except in one or two cases prices have not been paid which would be beyond the reach of any good dairyman keeping cows enough to warrant keeping a bull.

The herd is regularly tested for tuberculosis and abortion disease.

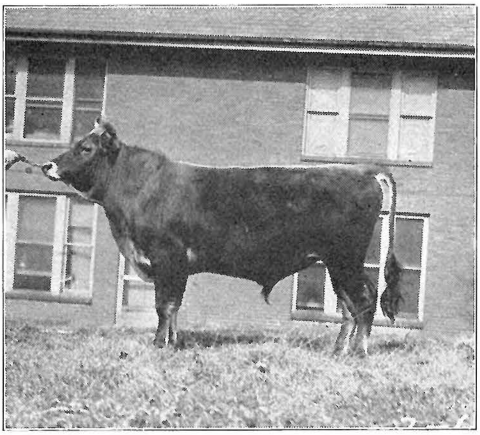

Fig. 1.—No. 313—Maplewood's Owl 312137

Official testing for advanced registry and register of merit is done only when it will not interfere with the use of the cows for experiments in progress. Some are tested while on experiments not conducive to highest production. Only a few have been milked more than twice daily. All Jersey cows now in the herd are register of merit cows with creditable records, including one gold medal and two silver medal records. All daughters to date of Choice Owl, the previous herd sire, have been good producers, capable of entering the register of merit, on two milkings daily.

The senior sire, No. 251, is a son of Oxford Lad's Owl of Dean Hill, with over 30 R. M. daughters, 11 of which had silver medal records. His dam, milked twice daily, has four good register of merit records, and his full sister has two silver medal records and a silver medal daughter. Jersey sire No. 313 is by a paternal half-brother to No. 251, and his dam has a record of 15,849 pounds of milk and 763 pounds of fat.

Less testing has been done among the Holsteins because more of them have been on experiments not favorable to testing.

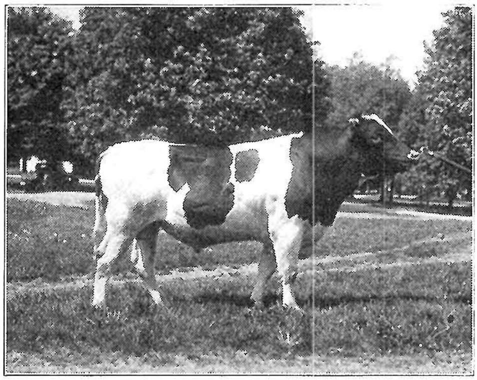

Fig. 2.—No. 281—Aaggie Risinghurst 538864

Holstein sire No. 263 was bred at the Station; his dam has a record of 19,400 pounds of milk and 803 pounds of butter. The dam of Holstein sire No. 281 is now on test and produced 100 pounds of milk in 24 hours and has averaged over 86 pounds of milk per day for 130 days; she was milked three times daily. At the end of 115 days she was milking 90 pounds daily.

The Station controls three other small herds located on county experiment farms in Trumbull, Belmont, and Hamilton counties. These herds are used for experimental work and farm management studies.

IMPROVED EQUIPMENT

Considerable improvement in the equipment for handling the Station dairy herd has been made during the past year. Extensive repairs have been made on the dairy barn; it has been painted and considerable new equipment has been installed. Three fourths of the floor space has been fitted with metal stalls and pens, which have greatly improved the convenience, sanitary conditions, and appearance. Space has been provided for over 50 cows and 44 head of young stock. There are, of course, still some improvements needed about the barn and surroundings.

THE COST OF KEEPING A BULL

The cost of keeping a bull on the dairy farm is a considerable item chargeable against the cows each year. This fact emphasizes the importance of keeping only proved bulls or high class young bulls whose progeny will be valuable and of the practice of economy in their management.

In a cost account study of some 20 farms in Medina County,[1] 16 farms, keeping bulls showed an annual cost varying from $66.73 to $192.03. The average cost was $124.33. The feed and pasture cost was $78.38. The feeds consumed per year averaged 1,587 pounds of grain, 3,405 pounds of silage, and 4,461 pounds of dry rough feeds. It was estimated that the dairymen who kept their bulls on pasture kept them at lower labor cost. The estimated time required to care for the bull varied from 48 hours to 191 hours per year, or a variation of 400 per cent. The average was 100.9 hours. The labor was charged at 30 cents per hour. The method of managing the bull had considerable to do with the cost.

Few of these bulls were allowed to run in pasture with the cows. It is not a safe practice. Stalls, pens, and pasture lots should be so arranged that the minimum of labor will be required in feeding and caring for the bull.

The average number of cows kept on these farms, where a bull was kept all or a part of the time, was 17, and the average cost per cow was $7.32.

Where bulls were kept all the time there were 12.4 cows per bull and the net cost per cow was $10.11. The average cost of service per cow where no bull was kept was $1.25. At this common charge for outside service the average bull would be required to sire 100 or more calves to repay his cost. It is evident that a dairyman with a small number of cows can not afford to keep a bull if a good one is available near by or if the common fee for outside service is charged.

COST OF FEEDING THE BULL

At the Experiment Station it is the custom to keep all mature bulls confined in boxstalls or pens under cover with outside pens. No pasture is available; therefore, a larger amount of feed is con-

[1]Ohio Agr. Ex. Sta. Bulletin 424, by F. L. Morison, Department of Rural Economics.

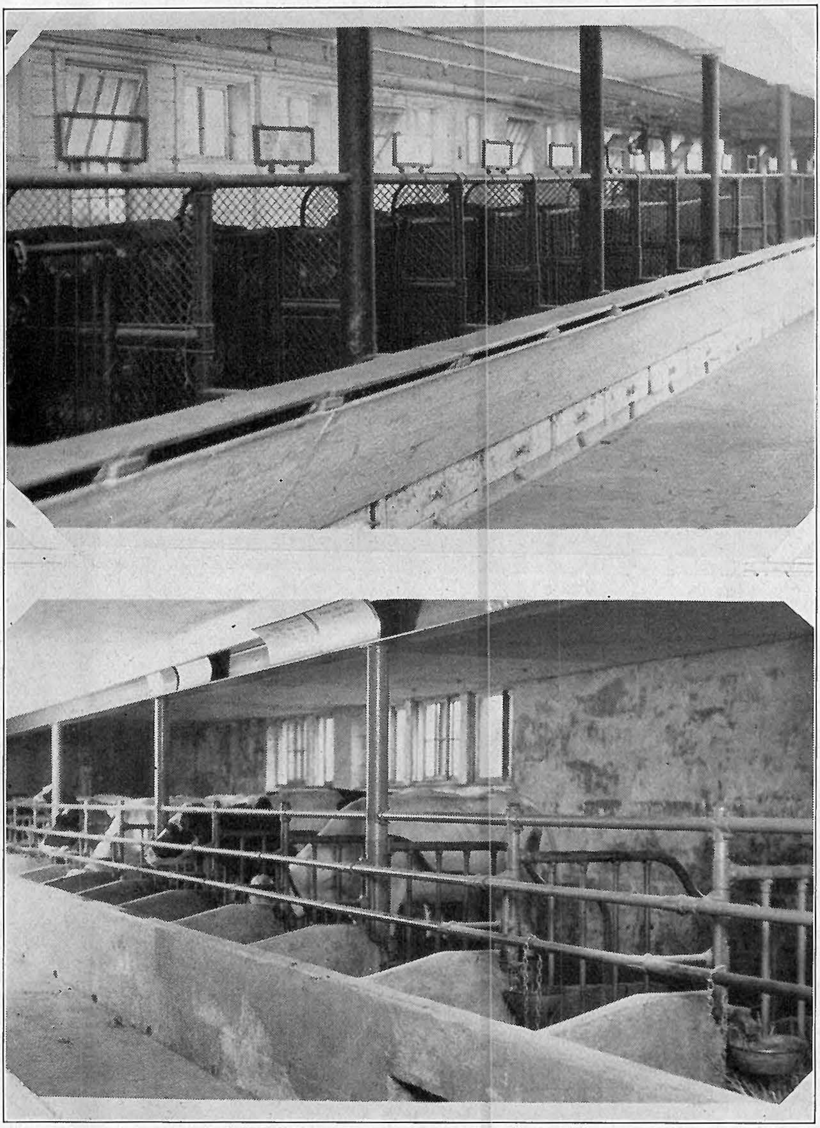

Fig. 3.—Two types of stalls in use in the Dairy Barn at the Ohio Experiment Station

sumed. The average feed consumed annually by bulls above two years of age is shown in Table 1.

TABLE 1.—Yearly Consumption of Feed by Bulls

	No. yearly records	Grain	Hay	Silage	Stover
		Lb.	*Lb.*	*Lb.*	*Lb.*
Jersey	29	2488	3029	1925	746
Holstein-Friesian	22	3287	3967	2037	281

These bulls were always kept in good breeding condition. At times probably they were in higher flesh than necessary. More grain and less hay were fed than indicated in the Morison report. This was done to keep the bulls from developing too large bodies, which interfere somewhat in service. With grain at $40, hay at $15, silage at $5, and stover at $8 per ton, the yearly cost of feed for Jerseys would be $80.27, and for Holsteins $101.71. This does not include labor and other costs.

PROCESSING FEEDS

The experimental work on processing feeds for dairy cows, a progress report of which was made in Circular 13, August 1928, has been continued.

During the winter of 1928-29 an experiment was conducted to determine the value of treating feeds with malt extract, the active principle of which is diastase.

The roughage of the two rations compared consisted of equal parts of corn stover and alfalfa hay, and the grain mixture consisted of 400 parts of corn, 300 parts of oats, 100 parts of wheat bran, and 100 parts of linseed oilmeal.

The roughage was run thru a silage cutter and the grain was mixed with it in proper proportion to make a balanced ration. The mixture was placed in a wooden tank where it was soaked and steamed and the temperature reduced to 140° F. or lower, a temperature suitable for the action of diastase. The mixture was divided into two parts, to one of which Diamalt, a malt extract, was added; both portions were allowed to stand for 12 hours, or long enough for the diastase to act. The portion to which the Diamalt was added developed invert sugar to the extent of 6 per cent of the dry matter in the feed. The sugar was derived from the starch of the grains while the roughage remained practically unchanged, there being no reduction of crude fiber as is often claimed for similar processes.

The portion to which no Diamalt was added developed very little invert sugar; no other chemical change was noted in the two portions. The treated and untreated feeds were fed alternately to two groups of cows, during two periods of 11 and 8 weeks.

Claims have been made that changing the carbohydrates to sugars by fermentation assists the cow greatly in utilizing the feeds. This test has shown that the change is not extensive and that it assists the cow but little. Her digestive system seems to be well adapted to do her own processing.

The ration treated with the Diamalt seemed a little more palatable and it was slightly better utilized but the gain in milk production was so small that it was not considered significant.

TABLE 2.—Feed Consumed; Milk and Fat Produced

Ration	Feed	Milk	Fat
	Lb.	*Lb.*	*Lb.*
Malted ration	23,473	7,661.0	319.8
Not malted	23,121	7,491.6	313.3
Gain	352	169.4	6.5
Gain, per cent	1.52	2.26	2.07
Net gain, per cent		.74	.55

This shows less than one per cent net gain in utilization of feeds.

No difference was detected in the general condition of the two groups of cows.

Considerable extra labor and expense were required to process the feeds and were not justified by the results in this case.

A similar experiment was conducted at the State Hospital at Orient, in which a commercial digester was used. The results have not yet been completely summarized.

These results are similar to those obtained by the Ontario, Canada, Station, with cows, and by this Station with steers. Therefore, we believe that Ohio dairymen would be wise to avoid such patented, or promoted, processes until more work is done by the Experiment Stations. No practical method has been discovered by which crude fiber and other indigestible parts of the feeds can be made readily digestible.

COMPARISON OF VARIETIES OF CORN FOR SILAGE

In cooperation with the Department of Agronomy the following figures respecting the yield and analysis of 10 leading varieties of corn for silage have been secured.

TABLE 3.—Yield and Composition of Varieties of Corn for Silage at Wooster

Variety	Yield per acre		Average composition as cut into the silo. 1925-29			
	15-year average	5-year average	Dry matter	Crude protein	Dry matter per acre	Crude protein per acre
	Tons	*Tons*	*Pct.*	*Pct.*	*Tons*	*Tons*
Blue Ridge	13.7	15.2	25.6	1.75	3.9	.266
Eureka	14.7	15.7	23.1	1.56	3.6	.245
Va. Horsetooth	....	15.3	24.3	1.85	3.7	.282
Old Virginia	....	15.6	20.9	1.60	3.3	.250
Boone County White	13.8*	15.9†	23.4	1.99	3.7	.316
Reid Yellow Dent	....	13.7	27.7	2.27	3.8	.311
Darke County Mammoth	11.3	13.6	26.5	2.22	3.6	.303
Leaming	9.5	11.5	33.2	3.10	3.8	.356
Sweepstakes Silage	....	10.0	37.3	3.00	3.7	.300
Clarage (Wooster)	8.6	10.5	31.2	2.30	3.3	.241

*Mostly southern Ohio seed.
†Seed from Kentucky and Indiana.

Blue Ridge, Eureka, Virginia Horsetooth, Old Virginia, and Boone County White are large, late-maturing varieties which seldom reach full maturity at Wooster. Reid Yellow Dent and Darke County Mammoth mature only in favorable seasons. Leaming has been for several years the favorite variety of corn for silage at the Wooster Station, and the above figures seem to indicate the wisdom of this selection. Both varieties will usually mature at Wooster. Clarage, another standard grain variety, seems to run somewhat lower than Leaming in yield of total dry matter and protein.

Sweepstakes, altho rather low in total green yield, has an exceptionally high dry matter and protein content so that the actual acre feeding value is practically as high as that of the larger varieties. It is early maturing and would seem to be a promising variety in localities having a short season or where planting is delayed.

Another advantage of varieties such as Leaming, Clarage, or Sweepstakes over the large varieties is that the amount of green corn necessary to supply a given amount of dry matter and protein would weigh only about ⅔ to ¾ as much and would occupy much less space in the silo.

INVESTIGATIONS REGARDING THE LEVEL OF PROTEIN FEEDING

These experiments were begun in 1911 shortly after the organization of the Station's dairy work as a separate department, and have been continued in various forms since that time as one of the major lines of study. Most of the earlier experiments in this field were of relatively short duration—such as winter feeding experiments on cows receiving pasture during the summer. Under such a plan the long-time effects of the use of the various experimental rations were largely a matter of conjecture.

Our experiment, therefore, called for the continuous year-round feeding of the respective rations, the cows being confined to dry-lot rather than pasture during the summer.

The proportion of protein in the ration, as expressed by the nutritive ratio, was the subject of study rather than the presence or absence of any particular feed or the absolute level of food consumption. Therefore, a considerable variety of feeds was used and the animals were allowed as much of the respective rations as they would consume without waste.

Rations ranging in nutritive ratio between 1 : 2 and 1 : 13 have been studied and compared for several years. Besides feeding, production, liveweight records, and notes regarding the condition of the cows, many analyses of feeds and milk have been made; several metabolism experiments making a balanced accounting of the intake and outgo of the more important food constituents have been conducted; and, quite recently, studies of the blood and urine by the most modern and delicate clinical methods have been under way. Some of the more important findings may be briefly stated as follows:

1.—The dairy cow is able to tolerate wide extremes in the protein content of her ration continuously over long periods without apparent detriment to her health. These experiments furnish no indication that rations having a nutritive ratio within the range of 1 : 4 and 1 : 11 are injurious to the health of the cow when the quality of the feeds is good.

We regard both the 1 : 2 and the 1 : 13 rations as dangerous; the one because of too much, the other because of too little, protein. Fortunately, no farm ration containing reasonable amounts of the common grains and roughages is likely to reach either of these extremes. Rations consisting entirely of low-grade roughage would fall in the 1 : 13 class, but these are obviously unsatisfactory and were not considered in our experiment.

Of the various protein feeding standards, that of Haecker, one of the lowest in protein now in popular use, provides liberal allowances in excess of the required minimum of protein. We, therefore, favor the use of the Haecker standard, at the same time calling attention to the fact that it is not a minimum standard as it has been considered by some writers and teachers.

Larger amounts of protein are used in other standards as a stimulus for more liberal production. Some results from these experiments indicate that increased total food consumption may often be more effective and economical than high protein content for inducing liberal production and keeping up the cow.

The wide extremes followed in the level of protein feeding have had very little influence on the composition of the milk produced, as measured by the ordinary methods of chemical analysis, except that very low protein rations seem to have a slightly depressing effect on the fat content of the milk. The use of delicate microchemical methods employed in blood analysis shows that the group of materials known collectively as "non-protein" nitrogen is decidedly higher in the milk of cows receiving the high protein ration, and that the same condition exists in the blood.

The differences in total amount and distribution of the various nitrogen-containing constituents in the urine of these cows is especially marked. This difference is shown in the accompanying table.

TABLE 4.—Nitrogenous Constituents of Urine from Cows on Rations of High and Low Protein Content

Rations received by cows	Total nitrogen in urine	Total nitrogen occuring as urea	Urea nitrogen in urine
	Pct.	*Pct.*	*Pct.*
N. R. 1: 13	.25	12.5	.03
Normally fed cows	1.40	65.9	.92
N. R. 1: 2	2.20	80	1.76

It is thought that when the optimum level of urea content for the urine is established this may furnish a valuable index of the state of nitrogen metabolism of the dairy cow.

PRACTICAL PROTEIN TEST AT HAMILTON COUNTY EXPERIMENT FARM

Two grain mixtures containing respectively 10 per cent and 30 per cent of high protein supplement (equal parts of choice cottonseed meal and linseed oilmeal) were compared. Each grain mixture consisted chiefly of equal parts of corn-and-cob meal and ground oats, and each contained 10 per cent of wheat bran. The one grain mixture contained 19 per cent total or 16 per cent digestible protein; the other 13.8 per cent total or 10.9 per cent digestible protein. One ration supplied approximately as much protein as called for by the Haecker Standard; the other about 75 per cent as much.

The Jersey herd was divided into two groups which were fed alternately in reverse order on the two grain mixtures, mixed hay and silage being fed to both groups alike.

The higher protein grain mixture produced somewhat more milk than the other. In the case of cows in the latter part of lactation the increased production did not pay for the extra cost of the grain; all grain and milk were figured at actual local prices.

In the case of fresh cows producing more liberally the increased production due to the use of the higher protein grain caused a substantial profit above increased cost of feed. These results are shown in Table 5.

TABLE 5.—Comparison of Feed Cost and Value of Milk

	6 cows in late lactation			5 fresh cows		
	Feed cost	Value of milk	Value of milk above feed cost	Feed cost	Value of milk	Value of milk above feed cost
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
High protein grain........	124.95	242.80	117.85	81.84	185.68	103.84
Low protein grain...	118.17	241.81	123.64	74.22	158.70	84.48

These results suggest that the discriminating use of two grain mixtures of different protein content, according to the stage of lactation and rate of milk production of the individual cow, may be a desirable and profitable practice for the dairyman to follow.

HIGH PROTEIN GRAINS FED TO COWS ON PASTURE NOT PROFITABLE

For two pasture seasons a grain mixture consisting only of corn 2 parts, oats and bran each 1 part, and containing 12 per cent protein has been compared in alternate periods with another containing these grains in the same relative proportion supplemented by 16⅔ per cent each of linseed oilmeal and corn gluten meal, making a 20 per cent protein mixture.

When the pasture was in best condition grain was the only additional feed, but in times of drouth and notably poor pastures silage was also fed. At such times nearly one half the nutrient requirement for maintenance and production was supplied by the grain and silage.

The difference in price of the two grain mixtures was $5.59 per ton, an average difference in cost of the respective grain mixtures per cow for the season of $1.96. In one season there was no increase in production due to the higher protein content; so the extra cost represented a loss of $1.96 per cow for the season. During the other season, when pasture conditions were less favorable, there was some increased production on the higher protein grain feeding, but the value of the increased product lacked 77 cents of paying for the extra cost of the grain. These results indicate that cows on good pasture do not need a high protein grain mixture. Altho it usually is good practice to feed good cows considerable grain while on pasture.

FAT-PROTEIN RELATIONSHIP IN NORMAL MILK

The many hundreds of analyses of milk made at the Station have been grouped and studied; they have brought out quite a definite relationship between the fat and protein content of milk.

In samples of milk testing 2.78 per cent butterfat the percentage of protein and fat are approximately equal. Above this point the protein increases approximately .42 times as fast as the fat. From this fact a formula has been deducted to determine the protein content when the fat content of milk is known. The formula is as follows:

$$\text{Protein} = 2.78 + .42\ (\text{Fat} - 2.78)$$

When both the fat content and protein content are determined this formula may be used as a check for the purity of the milk. Accuracy within about .25 per cent may be expected.

MINERALS

The mineral content of the dairy ration is quite important. Altho all feeds contain some minerals, the total amount of minerals supplied in a ration may vary widely due to the combination of feeds used. Two minerals that call for careful consideration are calcium and phosphorus. A knowledge of the amounts of these elements found in feeds will be useful in the planning of the feeding program.

In general, calcium is supplied by the legume hays, and phosphorus by the protein concentrates. The low calcium and phosphorus content of such feeds as timothy hay, corn, and oats deserves consideration. A ration composed of timothy hay as roughage with corn-and-oats chop for the concentrate, with or without silage, is a poor ration from the mineral standpoint.

In order to improve rations and to prevent possible mineral deficiencies, the use of mineral supplements has become general. When this practice was first adopted it was not known just how effective such a measure would be. There are now three long-time mineral feeding experiments on record.

The Massachusetts Experiment Station[2] has reported a mineral feeding experiment that lasted for 6½ years. During the first four years "tricalcium phosphate in the form of steamed bone meal specially prepared for animal feeding" was used; during the last two years a mineral mixture "consisting of 80% dicalcium phosphate (precipitated bone) and 20% carbonate of lime (ground limestone)" was used. These supplements were added to rations supposedly deficient in lime. Check groups were fed the same basal ration without the mineral supplements. We quote from their conclusions on steamed bone meal feeding as follows:

"In brief, the conclusion reached was that the benefit received from adding steamed bone meal to the ration of dairy cows under conditions existent in New England is very slight."

In regard to the dicalcium phosphate-limestone feeding they state: "The mineral supplement had little, if any, effect on the growth of the young cows and heifers. The low-ash ration apparently had no adverse effect on milk production, and the mineral supplement apparently had no favorable effect." The cows receiving the mineral supplement were a little nearer normal (in reproduction) and produced on the whole somewhat better calves than did those that did not receive it. The cows averaged 9000 pounds of milk yearly.

The conclusions reached at the Michigan Experiment Station[3] at the end of a 5-year mineral feeding investigation are: "...... the general need for mineral supplements for dairy cattle under normal milk conditions may be greatly exaggerated. It appears that mineral supplements supplying calcium are not greatly needed even when feeds such as timothy and other low-calcium roughages are used. This study further shows rather conclusively that raw rock phosphate should never be fed to cattle because of its detrimental effects, probably due to its fluorine content; and further, that complex mineral mixtures may be harmful if fed over long periods of time."

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[2]Massachusetts Agricultural Experiment Station Bulletin 255, November, 1929.
[3]Michigan Agricultural Experiment Station Technical Bulletin No. 105, February, 1930.

The Ohio Station has recently completed a supplemental mineral feeding experiment at the Trumbull County Experiment Farm, that lasted for five years and 11 months. Dicalcium phosphate (precipitated bone) was the mineral fed; this was mixed with grain at the rate of 2 per cent.

The results of this investigation can be briefly stated as follows: (1) the mineral supplement had little or no effect on milk and fat production (The group not receiving the mineral gave slightly more milk.); (2) the cows receiving the mineral got with calf with fewer breedings than the non-mineral group; (3) there were cases of abortion and permanent sterility in both groups. In general, any effect from feeding this mineral supplement was very slight. The milk production of this herd averaged well over 10,000 pounds, with some of the cows doing considerably better.

On the basis of the three experiments cited, it would appear that the use of mineral supplements was not attended with any marked benefits. As not all feeding conditions have been covered by these three experiments, it is obvious that the above results should not be interpreted to mean that mineral supplements are never necessary.

Fig. 4.—The Dairy Barn at Trumbull County Experiment Farm where Mineral Feeding Experiment was conducted

In the light of our present knowledge of the mineral nutrition of the dairy cow, the following are points which seem important:

1—If home-grown crops are fed, see that the land is well limed and phosphated because crops grown on fertile land are richer in minerals.

2—Since pasture grass is an excellent feed, increase the carrying capacity of pastures by treating with lime and phosphorus.

3—Feed high quality legume or mixed hays, since they not only are the chief source of calcium in the ration but are rich in that substance which helps the animal to make use of the minerals.

4—Care in curing hay is recommended; hay should be cut when not too ripe, and cured so as to retain a maximum amount of color and without undue leaching.

5—Cows should be allowed some exercise in the fresh air and sunlight (in winter as well as summer).

6—Supplementing a poor quality of roughage with a small amount of good roughage is an excellent way to feed mineral supplements.

7—The feeding of such a mineral supplement as steamed bone meal is recommended as a temporary insurance measure, in the case of high producing cows. Complex mineral mixtures are not recommended.

8—Individualism of cows seems to play a prominent role in the mineral problem. Building up a herd from cows that have shown vigor should be given consideration.

9—An adequate dry-period is emphatically recommended. During this period the cow seems to be able to store up some things which she is not able to do when producing milk. The dry cow should not be expected to subsist on roughage or pasture alone; a little bran or oilmeal should be included in her grain ration.

10—Care should always be taken to provide an adequate salt supply where the cow may have ready access to it.

11—Iodine is recommended when goitrous calves are produced; iodized salt fed during the latter half of pregnancy will overcome the goitrous tendency.

12—Mineral feeding will not cure abortion.

13—In general, if well-balanced rations are fed, the mineral problem does not seem so great as it was once thought to be. By "well-balanced ration" is meant, legume or mixed hays for roughage and a suitable grain ration containing some bran, oilmeal, cottonseed meal, etc.

14—Adding large amounts of ground rock and other inorganic sources of minerals does not seem to make up for a lack of the proper natural feeds.

15—Cod-liver oil has not given beneficial results with dairy cows.

16—Steamed bone meal, mixed with salt at the rate of 1 to 1, placed where the cows may have ready access to it, is a fine way to feed mineral matter. Another way is to add 1 pound of steamed bone meal to every 100 pounds of grain mixture.

17—A lack of minerals in the ration is indicated by cows licking dirt persistently or chewing on other materials not commonly thought of as cattle foods.

MANAMAR FOR GROWING HEIFERS

Manamar is a new proprietary feed made up of fishmeal, dried kelp, limestone, and salt. It offers some interesting innovations in feeding dairy cattle, inasmuch as it supplies an animal source of minerals and protein (in fish meal), an organic source of iodine (in kelp and fishmeal), vitamin D (in fishmeal), a calcium supplement (limestone), and other small amounts of material which may or may not be essential in cattle rations. The Manamar used in this work contained 93.5% dry matter, 33.63% protein, 36.98% total ash, 9.77% calcium, 1.5% phosphorus, and .011% iodine.

Purebred Jersey and Holstein heifers are being used in this trial. The heifers of each breed are paternal half-sisters; the dams of the heifers are also quite closely related, making unusually well matched lots. At the start of the experiments, Jan. 1, 1929, there were 13 heifers in the two groups; 6 more were added later as they became available.

The following grain mixtures were fed to the respective groups:

Check mixture		Manamar mixture	
Corn	4	Corn	4
Oats	3	Oats	3
Bran	1	Bran	1
Oilmeal	2	Oilmeal	1
		Manamar	1

In addition, both groups received mixed hay thruout the year; in summer limited pasturing replaced a part of the hay.

TABLE 6.—Weight and Height (at withers)—Jerseys

Heifer	Ration	18 months of age		24 months of age	
		Weight	Height	Weight	Height
		Lb.	*In.*	*Lb.*	*In.*
373 J	Check	597	45.25	715	46.50
374 J	Check	625	47.50	735	48.75
379 J	Check	747	47.50	898	49.25
388 J	Check	584	45.75	....	....
394 J	Check	Younger heifer		....	....
Average	....	638.25	46.50	782.7	48.17
371 J	Manamar	660	46.50	778	47.50
375 J	Manamar	Sick	....	720	49.50
383 J	Manamar	570	46.50	728	49.00
385 J	Manamar	541	45.50	....	....
390 J	Manamar	562	45.00	....	....
Average	....	583.3	45.88	742	48.67
Normal for Jerseys (Eckles)		572	45.5	716	47.4

TABLE 7.—Weight and Height (at withers)—Holsteins

Heifer	Ration	18 months of age		24 months of age	
		Weight	Height	Weight	Height
		Lb.	*In.*	*Lb.*	*In.*
377 H	Check	825	50.00	1047	51.50
378 H	Check	812	48.50	1003	51.25
380 H	Check	652	49.50	806	51.50
384 H	Check	721	50.00	874	52.50
386 H	Check	690	46.50	....	....
Average	....	740	48.90	932.5	51.69
376 H	Manamar	750	49.50	998	51.25
381 H	Manamar	679	50.50	818	51.75
382 H	Manamar	653	49.75	835	52.00
387 H	Manamar	734	49.25	....	....
Average	....	704	49.75	883.7	51.67
Normal for Holsteins (Eckles)		686	47.9	841	49.8

The only difference in the feeding of these two groups was in the replacing of one half of the oilmeal in the check ration with a like amount of Manamar. The rate of feeding hay and grain is regulated according to the liveweight of the animals; the same standard being used for both groups.

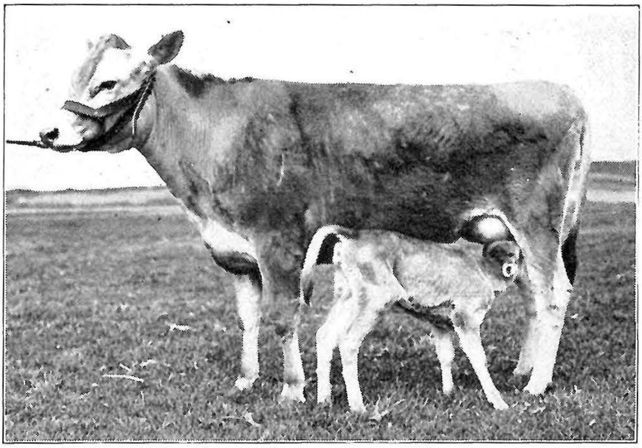

Fig. 5.—Heifer 373—Check heifer in Manamar-Oilmeal experiment. First in the experiment to freshen

From these data it will be seen that both groups are doing nicely, there being no outstanding difference between them. However, the application of these data is limited, since they refer only to weight and height at withers at the age of 18 months, and for some of the heifers 24 months.

Cost figures have not been considered. As Manamar is priced at over $100 per ton, it is at a disadvantage in comparison to oilmeal. However, it is felt that if the feeding principles involved in such a feed as Manamar may prove beneficial, the high cost may be justified; also, with development such feeds may be produced more cheaply.

These heifers will be continued on the experiment thru their first lactation period.

FISHMEAL FOR GROWING DAIRY HEIFERS

This is a companion experiment to the Manamar experiment. The general plan is the same as in the former, with the exception that fishmeal is being used instead of Manamar and is fed at the rate of 5% of the grain mixture; the check ration is the same as in the Manamar experiment. The fishmeal contains 60.3% protein. The two rations are approximately equivalent on a protein basis.

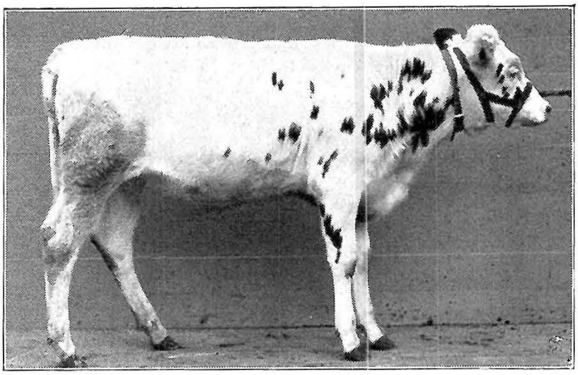

Fig. 6.—Holstein heifer on Fishmeal

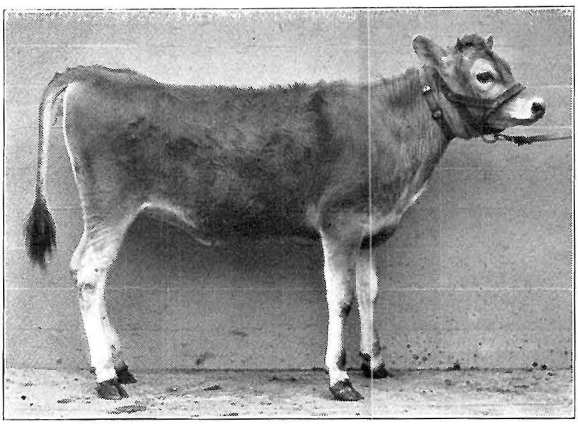

Fig. 7.—Jersey heifer on Fishmeal

SILAGE VS. WET BEET PULP-MOLASSES MIXTURE

In the last few years many have claimed that the acids of silage cause an acidosis in the cows which is said to be responsible for a loss of minerals from the body of the cow, thus causing decay of teeth and favoring breeding troubles and abortions.

The chief purpose in conducting this experiment was to compare some of the physiological reactions resulting from silage rations with those from non-acid rations. As silage is a succulent feed it was compared with another succulent feed, wet beet pulp mixed with molasses. The molasses was added chiefly for the sake of making the beet pulp more palatable.

Sixteen cows were used in this experiment, divided in groups as follows:

Group 1 consisted of 2 older cows, advanced in lactation. They were fed the wet beet pulp-molasses mixture thru the latter part of the lactation and up to freshening.

Groups 2 and 3 consisted of 4 Jerseys and 1 Holstein each. The groups were balanced with respect to period of lactation and other factors. One group was fed ordinary amounts of silage and the other a corresponding amount of beet pulp-molasses mixture. The rations fed the two groups were reversed each 50 days of the experiment.

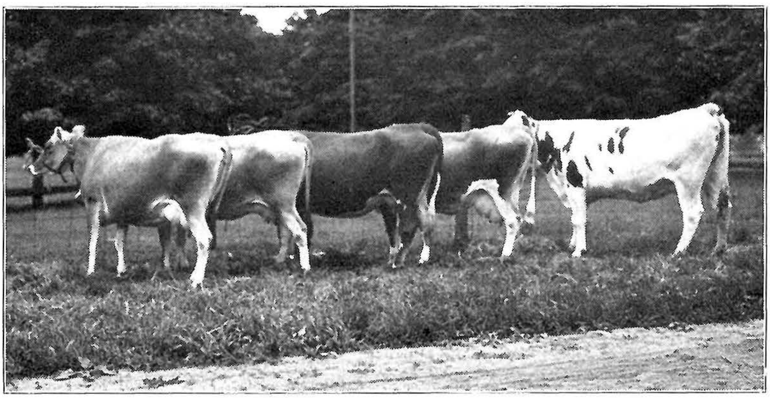

Fig. 8.—Group 2 produced 4,336.8 pounds of 4% milk on the beet pulp ration, and 4,146.9 pounds on the corn silage ration

Group 4 consisted of 4 fresh cows fed large amounts of silage and wet beet pulp-molasses mixture in alternate periods.

The wet beet pulp-molasses mixture was made by adding 2 pounds of blackstrap molasses to every 10 pounds of dried pulp, and mixing with 30 pounds of water. The cows were fed liberally, grain being given in amounts comparable to test feeding.

During the course of the experiment it became necessary to feed, for a time, from another lot of silage which was of poorer quality than the original. However, the production of the cows in Group 3 receiving both lots of silage showed little or no effect from the change. They gave 3,634.9 pounds of 4-per cent milk for the 30 days preceding the change and 3,644.5 pounds for the 30 days after the change in silage.

EFFECTS OF SILAGE AND WET BEET PULP ON COWS' SYSTEMS AS MEASURED BY CHEMICAL CONSTITUENTS IN THE URINE

Among the symptoms of acidosis are very low bicarbonate content, increased acidity, and ammonia content of the urine. These and other points were determined in the urine of the four groups listed above. While some slight differences were shown by the groups, these were not sufficiently striking and constant to be of any special significance even in the case of cows in Group 4 receiving as much as 50 pounds of these feeds daily. Cows, as ordinarily fed on good rations, consume an abundance of acid-neutralizing elements. Moreover, the organic acids, such as lactic and acetic, which are the chief acids of silage, are largely destroyed in the process of digestion and hence lose their acid reactions.

MILK PRODUCTION

For the comparison of milk production from the two feeds only Groups 2 and 3 were considered, as these were the only ones where the double reversal plan of experiment was used. In the accompanying table the productions of Groups 2 and 3 are given for both feeds. A little more milk and butterfat were produced in the periods when the wet beet pulp-molasses mixture was fed, the difference being 5%.

TABLE 8.—Total Production of 4 Per Cent Milk, Both Groups

	On silage	On beet pulp
	Lb.	*Lb.*
Group 2	4146.9	4336.8
Group 3	4869.0	5152.5
Total	9015.9	9489.3
Difference		+473.4
Difference, per cent		5.2

The change from silage to beet pulp was accompanied by increased milk production by 9 of the 10 cows. (The two groups were alternated). The production of Group 3 while on beet pulp for the last period of 40 days was higher than that for the first period on the good silage. These five cows were averaging more milk at the end of the experiment than they were at the beginning, 150 days earlier.

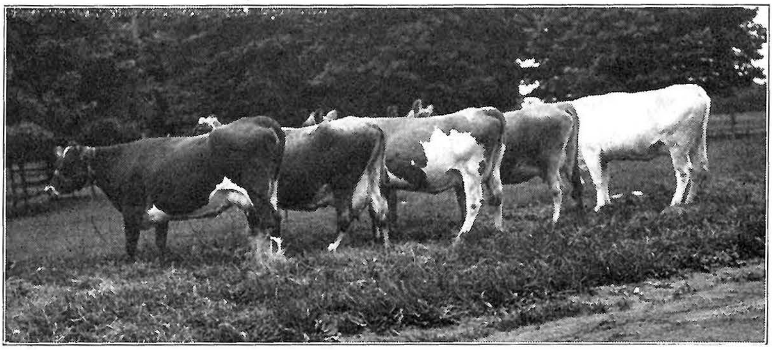

Fig. 9.—Group 3 produced 4,869.0 pounds of 4% milk on silage ration, and 5,152.5 pounds of 4% milk on beet-pulp ration

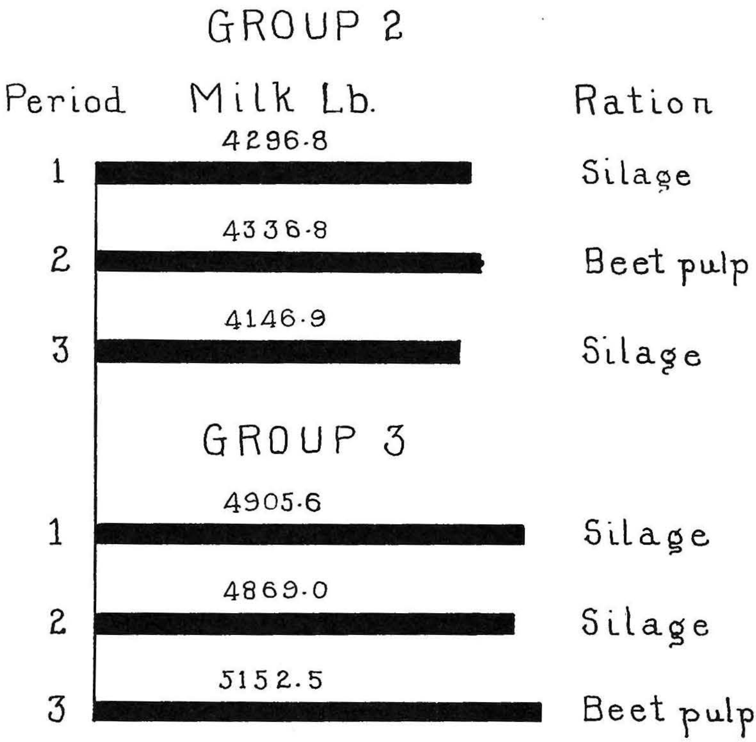

Chart 1.—Total production of 4 per cent milk in 40-day periods

Altho the price of beet pulp fluctuates, it is generally higher than silage and under ordinary conditions is not an economical substitute for silage. In test rations, with cows consuming large amounts of feed, it has been considered a fine succulent for keeping the cow in condition. The dairyman with too few cows to warrant a silo may find beet pulp desirable, and probably more economical than field beets or various processing systems of making hays into a succulent. The wet beet pulp-molasses mixture as used in this experiment was much relished by the cows.

STUDIES ON THE FOOD VALUE OF MILK

THE EFFECTS OF HIGH AND LOW PROTEIN RATIONS

ON THE VITAMIN CONTENT OF MILK

Since a marked difference was noted between the physical condition of the cows receiving the high protein ration and those receiving the low protein ration, the question arose as to whether or not the milk produced by the cows in each of these groups differed. No significant difference in chemical composition had been detected by routine chemical analyses of samples of milk from these two groups of cows over a number of years. Consequently other differences were looked for.

The amount of vitamins A, B, and D in the two milks was determined and compared with the potency of normal milk in these same vitamins. No significant differences in vitamin content were found. The slight differences observed could be attributed to the nature of the roughages fed rather than to the amount of protein in the ration.

ON THE TOTAL NUTRITIVE VALUE OF MILK

If test animals are fed a diet consisting entirely of one food, such as milk, the rate of growth and physical condition of such animals should be a measure of the total value of the nutrients, minerals, and vitamins in the milk for growth.

On this basis groups of rats were fed nothing but milk from cows receiving the high-protein, low-protein, and normal rations. Since it was known that rats fed nothing but milk develop nutritional anemia, sufficient copper and iron were added to the milk to prevent this. Some superiority was shown by the milk from the low-protein group of cows, as indicated in Table 9.

TABLE 9.—Effect of Milk from High-Protein, Low-Protein, and Normal Cows on Growth of Rats

Group	Sex of rats	Gain in weight (12 weeks)	Gain per 100 cc. milk consumed
	No.	*Gm.*	*Gm.*
High-protein	3 females	77	2.09
	5 males	96	2.52
Low-protein	3 females	98	2.55
	5 males	110	2.86
Normal	4 females	87	2.26
	4 males	96	2.50

Thus far neither chemical composition nor vitamin content could be held responsible for the slightly superior total nutritive value of the milk from cows fed the low-protein ration. Another means of determining the cause of this lay in the biological value of the proteins in the milk. For example, two foods may have identical amounts of protein, but upon digestion one may yield quite different products (amino acids) than the other. By allowing the foods under consideration to furnish the only source of protein in an otherwise complete diet, a means is afforded for measuring the relative values of the proteins of those foods.

ON THE BIOLOGICAL VALUE OF THE PROTEIN OF MILK

With this in mind, samples of skimmilk powder were prepared from each group of cows and fed as the only source of protein to rats receiving an otherwise complete diet. Slight superiority was shown by the protein in the skimmilk powder prepared from milk produced by the low-protein cows, Table 10, but before a definite evaluation can be made further work, using more animals and different levels of protein intake, must be carried out.

TABLE 10.—Biological Value of Proteins of Milk from Cows on High-Protein, Low-Protein, and Normal Rations

Group	No. of rats	Gain per gram of protein intake
		Gm.
High-protein	5	1.97
Low-protein	4	2.12
Normal	6	2.00

THE VITAMIN CONTENT OF MILK

EFFECT OF THE COW'S RATION ON THE VITAMIN-B AND VITAMIN-G CONTENT OF MILK

Until quite recently vitamin B was the term used to designate what was supposed to be a single accessory food substance. It is now known that what was formerly called vitamin B contains at least two factors, one of which is called vitamin B and the other vitamin G. Vitamin B is concerned with the nervous system and prevents the disease known as beri-beri in man. Vitamin G prevents the disease in man known as pellagra. Since milk had been considered a fair source of the vitamin B complex it became necessary to determine its relative potency in the two factors making up the B-complex. It was found that milk from cows under winter feeding conditions is a poor source of vitamin B and an excellent source of vitamin G.

Since some evidence exists that vitamin B is quite essential for the proper development of infants an attempt was made to increase the amount of this factor in milk by feeding the cow. Uncompleted work indicates that neither pasture grass nor dried yeast are effective in bringing this about.

EFFECT OF THE COW'S RATION ON THE VITAMIN-D CONTENT OF MILK

As milk is ordinarily produced it contains but a very small amount of vitamin D, the factor concerned with proper bone and tooth formation. Vitamin D prevents rickets in children and it is for this reason that feeding cod-liver oil or some other substance rich in vitamin D is recommended during the winter months. Owing to parents' unfamiliarity with the facts or to lack of funds, many children must rely upon milk for their supply of vitamin D. Some practical method of producing milk sufficiently potent in the anti-rachitic factor so that when the required amount is consumed the vitamin D requirement of the child is satisfied would be an ideal worth striving for.

With this in mind, various substances containing vitamin D have been fed to cows and the anti-rachitic potency of the resulting milk or butterfat determined.

Manamar, a commercial feed containing fish meal and kelp, having been found to be a good source of the anti-rachitic factor, was tried. The Jersey herd of the Belmont County Experiment Farm was divided into two groups. One group was fed Manamar (See page 23). An aliquot sample of milk from four consecutive milkings from each group was collected. The Holstein herd at the Trumbull County Farm was similarly fed (See page 35), and samples of milk were obtained as above from six successive milkings. The cream from these samples was churned and the butter rendered into pure fat.

The samples of fat collected from each herd were then assayed for vitamin D by the prophylactic method at levels of 0.4 gram and 0.8 gram per rat per day. The ash content of the femurs and the inorganic phosphorus of the blood of rats indicated no increase of vitamin D in the fat of cows fed Manamar or fish meal and kelp over that found in fat from the check groups.

Irradiated ergosterol, the most potent source of vitamin D known, was fed to cows at levels of 5, 10, 25, 50, and 100 milligrams a day. No improvement in the vitamin-D content of the butterfat was noted after feeding 5 or 10 milligrams. At the 25-milligram level there was some indication that the vitamin-D content of the butterfat was slightly improved. A decided increase in antirachitic potency of the fat resulted when 100 milligrams were fed.

While feeding irradiated ergosterol to cows is not now practical, should later trials confirm the preliminary report here given, a means of producing this product so as to make its cost reasonable will undoubtedly be devised.

IS MILK A COMPLETE FOOD?

Milk is the most nearly perfect food known to man, but it is not a complete food. This is evidenced by the fact that weanling rats placed on an exclusive milk diet soon die from nutritional anemia. The addition of small amounts of copper and iron to the milk allows the rats to grow and reproduce, as shown in Table 11.

TABLE 11.—Reproduction of Rats on an Exclusive Milk Diet and on a Supplemented Milk Diet

Diet	Litters	Total young	Young reared	
	No.	*No.*	*No.*	*Pct.*
Milk alone	0	....	....	....
Milk plus iron	0	....	....	....
Milk plus copper	3	24	8	33
Milk plus copper and iron	12	80	16	20

The number of young per litter born is practically normal, but only a few young are raised. This would indicate that either another factor is missing from milk or that an insufficient quantity of milk can be consumed by the lactating rat to meet the heavy drain of nursing young.

It has been claimed by some that manganese, when added to milk together with iron, is as effective in hemoglobin regeneration as is the combination of copper and iron. Experiments just completed by this department do not confirm this contention.

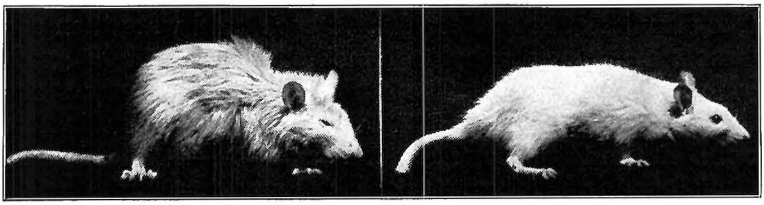

Fig. 10.—A—Rat fed milk alone

This rat fed milk alone became anemic; hemoglobin content of blood 10 per cent of normal.

B—Fed milk and iron and copper

The same rat after receiving for two months daily doses of iron and copper; hemoglobin content of blood 100, or normal.

IODIZED MILK

EFFECT ON THE THYROID GLAND

It having been shown that iodized milk can be readily produced by feeding cows some form of iodine, it seemed necessary to determine whether such a procedure would be of any particular advantage or disadvantage. Consequently, milk from cows receiving one tenth of 1 gram of potassium iodide daily was compared with milk from cows receiving no iodine other than that present in their feed and drinking water. This milk, fed at the rate of 50 cc. per rat daily, plus iron and copper, constituted the only food given to weanling rats over a sufficient period to measure its value for growth. Another group of rats received the normal milk to which was added, in addition to copper and iron, sufficient potassium iodide to make the daily intake of iodine equivalent to that received in 50 cc. of the iodized milk. A fourth group was fed one-half iodized milk and one-half normal milk by volume.

In view of the fact that iodine and goiter are closely related, particular attention was paid to the thyroid glands of these rats. The size and iodine content of the thyroid would be an indication of the value of iodized milk in preventing enlargement of this gland. On the other hand, it was of equal interest to determine what the effect would be of feeding iodized milk when the thyroid was already enlarged. To do this rats were fed a basal diet which had

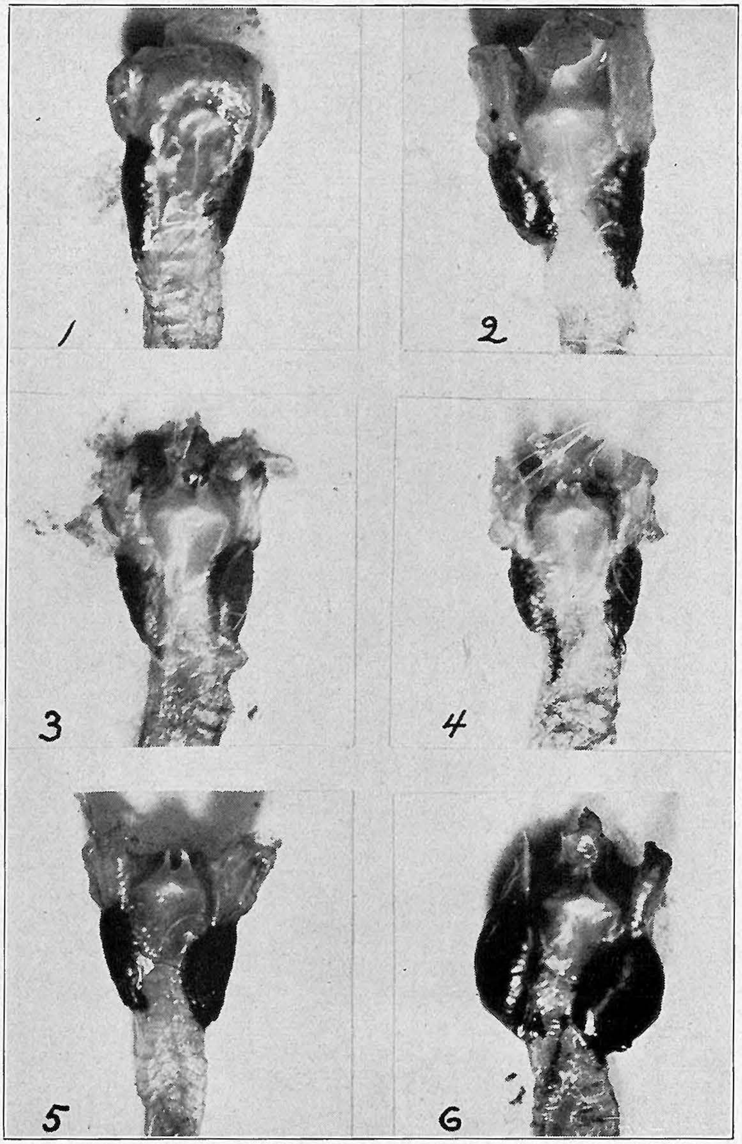

Fig. 11.—Showing effect of iodine on thyroid glands of rats

1. Control diet 4 weeks; then 0.000025 gm. iodine as KI daily for 4 weeks, plus ultra-violet light three times a week.
2. Control diet 4 weeks; then 50 cc. of normal milk daily.
3. Control diet 4 weeks, 50 cc. of iodized milk daily 4 weeks.
4. Stock diet.
5. Control diet for 4 weeks.
6. Control diet 4 weeks, then plus ultra-violet light three times a week for 4 weeks.

been found to produce enlarged thyroids after four weeks. Then iodine, as potassium iodide, or iodized milk, was added each day for four additional weeks.

TABLE 12.—Effect of Potassium Iodide and of Iodized Milk on the Size and Iodine Content of the Thyroid Gland of Rats

Prophylactic Method

Group	Series I			Series II			Series III		
	No. of rats	Gland wt. (fresh) per 100 g. body wt.	Iodine in dry gland	No. of rats	Gland wt. (fresh) per 100 g. body wt.	Iodine in dry gland	No. of rats	Gland wt. (fresh) per 100 g. body wt.	Iodine in dry gland
		Gm.	*Per cent*		*Gm.*	*Per cent*		*Gm.*	*Per cent*
Normal milk	7	0.0056	0.063	4	0.0051	0.139	6	0.0085	0.203
N.-M. plus 0.025 mg. I_2	8	0.0049	0.431	......	....	....	6	0.0066	0.396
N.-M. plus 0.05 mg. I_2	5	0.0054	0.672	......	....	....	......	....	....
N.-M. plus 0.0125 mg. I_2	4	0.0075	0.279	......	....	....	......	....	....
Iodized milk	7	0.0054	0.511	3	0.0042	0.363	6	0.0057	0.496
½ iodized ½ normal	5	0.0054	0.597	4	0.0034	0.376	6	0.0060	0.561

Curative Method

Group	No. of rats	Wt. of thyroid (fresh)	Wt. of thyroid (dry)	Iodine in dry gland
		Gm.	*Gm.*	*Per cent*
Stock rats 8 weeks old	4	0.0093	0.0024	0.138
Basal diet* for 4 weeks	11	0.0238	0.0046	0.058
B. D. for 4 weeks then plus U. V. R.†	8	0.0228	0.0049	Trace
B. D. for 4 weeks then plus U. V. R. and 0.025 mg. I_2	10	0.0103	0.0031	0.407
B. D. for 4 weeks then 50 cc. normal milk	9	0.0113	0.0030	0.213
B. D. for 4 weeks then 50 cc. iodized milk	10	0.0099	0.0027	0.510

*Yellow corn 76, wheat gluten 20, calcium carbonate 3, and salt 1.
†U. V. R.=Ultra-violet radiation.

At the end of the trials the rats were killed and the lobes of their thyroid glands removed. These were weighed, dried, weighed again, and their iodine content determined. The results are summarized in Table 12.

From this work it can be concluded that the iodine in iodized milk exerts as great an influence on the size and iodine content of the thyroid gland of rats as does an equivalent amount of iodine administered directly or added to normal milk.

Whether or not the production of an iodized general milk supply is justified will depend upon results obtained with children under medical supervision.

EFFECT ON GROWTH OF RATS

In the above trials growth and food consumption records were kept. These reveal the following information:

TABLE 13.—Effect of Potassium Iodide and of Iodized Milk on the Growth of Rats

Series I and II

Group	Rats	Gain in weight (12 weeks)	Gain per gram of protein intake
	No.	*Gm.*	*Gm.*
Normal milk	11	109	0.806
Normal milk plus 0.000025 gm. iodine as potassium iodide	8	113	.843
Iodized milk	10	92	.773
½ iodized milk, ½ normal milk	9	105	.777

Series III

Group	Rats	Gain in weight	
		In eight weeks	Per 100 cc. of milk
	No.	*Gm.*	*Gm.*
Normal milk	6	81	3.645
Normal milk plus 0.000025 gm. iodine as potassium iodide	6	84	3.775
Iodized milk	6	86	3.856
½ iodized milk, ½ normal milk	6	79	3.509

The smaller gains in weight made by the rats receiving iodized milk in Series I and II may be attributed to the consumption of a smaller amount of milk, as some difficulty was experienced in getting the rats in this group to consume their quota. That less food intake was responsible for the smaller gain is evident from Series III in which the food intakes were practically identical and the gains much the same.

EFFECT ON GROWTH OF CALVES

The value of iodized milk for growth in calves was compared with that of normal milk. Two groups of calves were fed a basal ration of alfalfa hay, corn, bran, and linseed oilmeal. In addition, one group received normal whole milk; the other group received iodized whole milk. The milk feeding was so regulated that each calf of each breed received approximately the same amount of milk over the entire feeding trial. Over a five-months' period, the calves receiving iodized milk made slightly better daily gains and looked better physically than did those receiving normal milk.

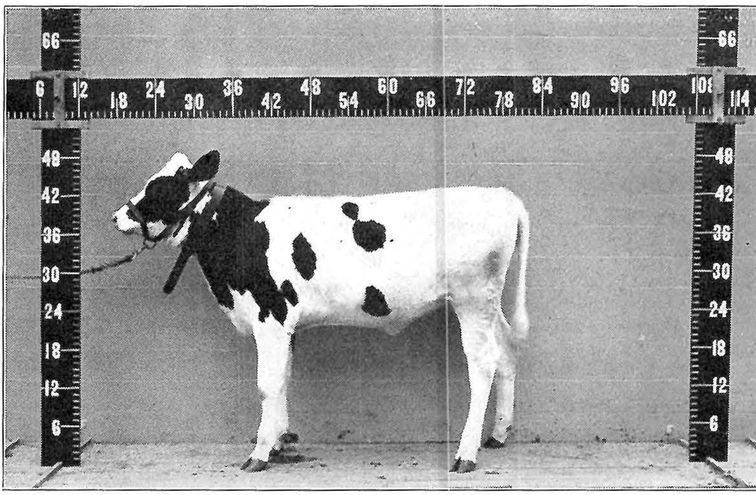

Fig. 12.—Calf No. 407—Fed normal Holstein milk
Age—6 months
Weight—414 pounds
Height at withers—41.5 inches

In the following table, data for two Jersey heifer calves, one Jersey bull calf, three Holstein heifer calves, and two Holstein bull calves are included for each group:

TABLE 14.—Effect of Iodized Milk on Growth of Calves

	No. of calves	Av. daily gain
		Lb.
Normal milk	8	1.58
Iodized milk	8	1.70

In addition to making slightly better gains, the calves receiving iodized milk had a better finish as evidenced by the condition of the hair and skin.

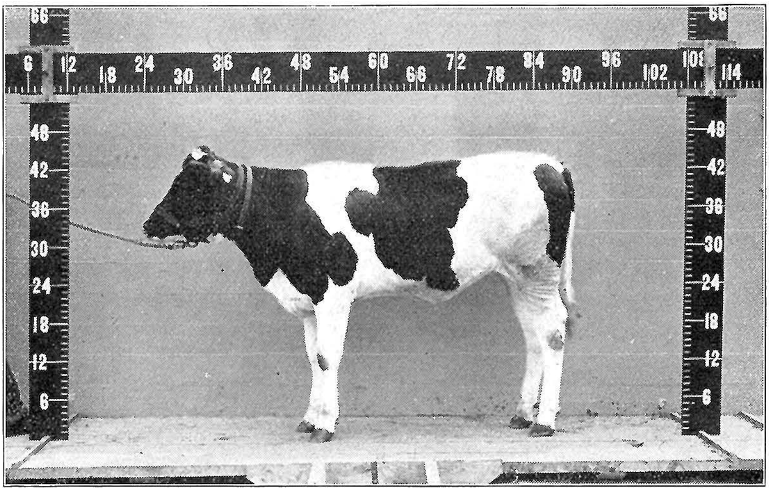

Fig. 13.—Calf No. 408—Fed iodized Holstein milk
Age—6 months
Weight—446 pounds
Height at withers—43.0 inches

SKIMMILK POWDER FOR CALVES

An experiment on skimmilk powder for calves was conducted on the Trumbull County Experiment Farm. The results of this work have been published in detail in the Bimonthly Bulletin for March-April, 1929, and November-December, 1929.

It was found in this work that when whole milk is sold the use of skimmilk powder affords a satisfactory, economical system of raising calves. The powder may be mixed with warm water (1 part of powder to 9 of water) and fed just as ordinary skimmilk is fed, or it may be mixed with the grain after the calves have made a good start on the liquid remixed skimmilk.

It was also found as a result of this work that satisfactory calves can be grown when milk is removed from their ration after 60 days. Excellent calves were raised when milk feeding was omitted after the calves were 90 days or 120 days of age. This indicates that skimmilk powder need not be fed for more than 90 to 120 days. This does not mean that when plenty of liquid skimmilk is available it should not be fed for a longer period.

DAIRY PUBLICATIONS OF THE EXPERIMENT STATION, WOOSTER, OHIO

BULLETINS

267, The value of soybean and alfalfa hay in milk production.

289, Raising dairy heifers, cost, feeding, and care.

327, Clover vs. alfalfa hay for milk production.

334, Dairy production in Ohio.

295, 308, 330, and 363, Mineral metabolism of the milch cow.

347, Utilization of calcium compounds in animal nutrition.

369, Field corn and silage corn for silage.

370, Losses and exchanges of material during the storage of corn as silage.

376, The effect of high and low protein content on the digestibility and metabolism of dairy rations.

389, Protein requirement of dairy cows.

455, Dicalcium phosphate as a mineral supplement for dairy cows.

CIRCULARS

122, Testing the dairy cow.

128, Feeding dairy cows.

134, The care of cream.

135, Building up the dairy herds of Ohio.

136, Care of the dairy herd.

SPECIAL CIRCULARS

13, August, 1928. Dairy work. Experiments under way and references to completed work and publications of the Department of Dairy Industry.

29, August, 1930. Dairying at the Ohio Agricultural Experiment Station.

MONTHLY BULLETIN ARTICLES

Feb. 1916, Beets and mangels compared with silage for milk production.

May 1916, Heavy silage vs. heavy grain feeding for dairy cows.

July 1916, Influence of dairy sires on production.

Aug. 1916, Does it pay to take extra care of cows?

Oct. 1916, Variations in the composition of skimmilk.

Dec. 1916, Misguided appetite and the high cost of living (Food value of milk).

Jan. 1917, Feeding situation (Winter dairy rations).

Feb. 1917, Low grade cottonseed meal.

June 1917, Cost of milk production.

Sept. 1917, Raising dairy heifers, costs.

Oct. 1917, Economy of production by dairy cows.
Nov. 1917, Nutrients returned by dairy cows.
Dec. 1917, Stage of lactation affects milk yield.
Dec. 1917, Roughages for milk production.
Apr. 1918, A neglected source of valuable human food (Cottage cheese, food value, manufacture, and sale).
Oct. 1918, Manurial value of dairy feeds.
Dec. 1918, How to determine the cost of milk—I.
Dec. 1918, Centrifugal recovery of cheese from buttermilk.
Jan. 1919, How to determine the cost of milk—II.
July 1919, Ohio Experiment Station dairy herd.
Sept. 1919, Recovering cottage cheese curd from buttermilk.
Oct. 1919, Home-mixed or proprietary feeds for the dairy herd.
Dec. 1919, Usefulness of production records in dairy management.
Sept. 1921, Crop rotations for a dairy farm.
Apr. 1922, A case of twinning in dairy cattle.
Dec. 1922, May 1923, Raising and feeding dairy steers.
Dec. 1923, Abnormal fermentation in milk (ropy milk).

BIMONTHLY BULLETIN ARTICLES

March-April, 1925, Minerals in the dairy ration.
May-June,1925, Selecting foundation dairy cows.
July-Aug., 1925, Alfalfa and clover hay for dairy heifers.
Jan.-Feb., 1926, A dairy cow, Grace Daw 2d, and her progeny.
May-June, 1926, Alfalfa and soybean hay for growing heifers.
July-Aug., 1926, Soybeans and soybean oilmeal for milk production.
Sept.-Oct., 1926, Soybean hay and soybean silage.
Nov.-Dec., 1926, Liberality and economy in feeding of dairy cows.
March-April, 1927, Butterfat tests of first and later lactations.
Jan.-Feb., 1928, Hay for dairy cattle.
March-April, 1928, Effect of high and low protein rations on milk for calves.
March-April, 1928, Succulent dairy feeds.
May-June, 1928, High protein grains supplement to pasture for dairy cows.
May-June, 1928, Gold medal cows in station dairy herd.
July-Aug., 1928, The possibility of producing iodized milk.
Sept.-Oct., 1928, A study of certain processes for fermenting or enzymatizing feeds.
Nov.-Dec., 1928, The effect of the cow's ration on the food value of milk.
Nov.-Dec., 1928, The effect of the cow's ration on the vitamin-A and vitamin-B content of milk.
Jan.-Feb., 1929, Preparing grain mixtures of specified protein content.
Mar.-Apr., 1929, Powdered skimmilk as a feed for dairy calves.

Mar.-Apr., 1929,	The effect of the cow's ration on the vitamin-D content of milk.
May-June, 1929,	High protein grains. Are they needed as a supplement to pasture for dairy cows, II?
Nov.-Dec., 1929,	How long should Holstein calves receive milk?
May-June, 1930,	Dicalcium phosphate as a mineral supplement for dairy cows, I. Effect on health.
July-Aug., 1930,	Dicalcium phosphate as a mineral supplement for dairy cows, II. Effect on milk production.

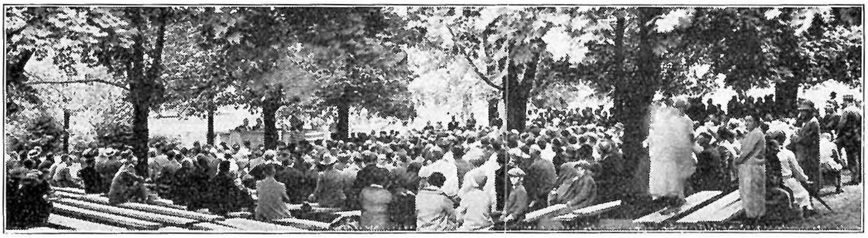

Fig. 14.—Our first Dairy Day

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